DOCUMENT RESUME

ED 209 103 SE 035 845

AUTHOR Blosser, Patricia E.
TITLE ERIC Clearinghouse for Science, Mathematics, and Environmental Education Science Education Fact Sheets, Nos. 1, 2, 3, 4, 1981.
INSTITUTION ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY National Inst. of Education (ED), Washington, D.C.
PUB DATE 81
CONTRACT 400-78-0004
NOTE 9p.
AVAILABLE FROM Information Reference Center (ERIC/IRC), The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 (subscription for four factsheets $1.00; back issues and single copies $1.00).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Controversial Issues (Course Content); *Creationism; Elementary School Science; Elementary Secondary Education; *Evolution; Gifted; *Resource Materials; *Science Activities; *Science Careers; Science Curriculum; Science Education; Science Instruction; *Science Laboratories; Secondary School Science; Special Education
IDENTIFIERS Science Education Research

ABSTRACT

Four science education fact sheets are presented and focus on: (1) creationism vs. evolution; (2) science careers; (3) science activities for special students; and (4) the role of the laboratory in science teaching. The first fact sheet was prepared to assist teachers, curriculum coordinators, and others in dealing with the teaching of evolution vs. creationism by providing a bibliography of documents and journal articles found in the ERIC data base. The second fact sheet was designed to provide users with information about terms they may use in searching ERIC and to provide a listing of documents and journal articles obtained from an ERIC search using the descriptor "Science Activities" in combination with descriptors related to special students. The last fact sheet focuses on various aspects of the role of the laboratory in science instruction, including what literature is available in ERIC and an overview of the research on the use of science laboratories. (DS)

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ERIC/SMEAC Science Education Fact Sheet Number 1

1981

Teaching Controversial Issues in the Science Classroom: Creationism vs. Evolution

The conclusion of the Scopes trial in Tennessee apparently did not settle the issue of evolution vs. creationism. Teachers are still requesting assistance in handling the pressures of fundamentalist creationist groups demanding equal time. In 1976 the National Science Teachers Association published, in *The Science Teacher* (November issue), the organization's position statement entitled "Inclusion of Nonscience Theories in Science Instruction." This position statement follows:

> *Throughout his recorded history, man has been vitally concerned in finding out all that he can about his universe. He has explored it in many ways, raised questions about it, designed methods by which he could increase and organize his knowledge, and developed systems to aid him in understanding and explaining his origin, and nature, and his place in the universe. Among these systems are philosophy, religion, folklore, the arts, and science.*
>
> *Science is the system of knowing about the universe through data collected by observation and controlled experimentation. As data are collected, theories are advanced to explain and account for what has been observed. The true test of a theory in science is threefold: (1) its ability to explain what has been observed, (2) its ability to predict what has not yet been observed, and (3) its ability to be tested by further experimentation and to be modified as required by the acquisition of new data.*
>
> *The National Science Teachers Association upholds the right and recognizes the obligation of each individual to become informed about man's many endeavors, to understand and explain what each endeavor has contributed to mankind, and to draw his own conclusions in each area.*
>
> *The National Science Teachers Association also recognizes its great obligation to that area of education dealing with science. Science education cannot treat, as science, those things not in the domain of science. It cannot deal with, as science, concepts that have been developed in other than scientific ways. Moreover, the National Science Teachers Association vigorously opposes all actions that would legislate, mandate, or coerce the inclusion in the corpus of science, including textbooks, of any theories that do not meet the threefold criteria given above. (p. 59).*

To assist science teachers, curriculum coordinators, and others in dealing with the teaching of evolution vs. creationism, this fact sheet has been prepared to provide a bibliography of materials on this topic found in the ERIC data base. Both documents and journal articles are included; documents may be identified by ED numbers; journal articles, by EJ numbers. Abstracts of documents are found in *Resources in Education* (RIE). Annotations of journal articles are found in *Current Index to Journals in Education* (CIJE). Both are monthly publications.

Abraham, Michael R. and Fred W. Fox, eds.
1979 AETS Yearbook, Science Education/Society: A Guide to Interaction and Influence.
ED 164 360 RIE, May, 1979

Alexander, Richard D.
"Evolution, Creation, and Biology Teaching"
American Biology Teacher 40(2):91-104,107, February, 1978.
EJ 187 274 CIJE, 1979.

Aulie, Richard P.
"The Origin of the Idea of the Mammal-like Reptile."
American Biology Teacher 36(8):476-484-511, November, 1974.
EJ 107 922 CIJE, 1975

Bergman, Jerry
"Teaching About the Creation/Evolution Controversy. Fastback 134."
ED 178 401 RIE, March, 1980

Bird, Wendell R.
"Creationism and Evolution: A Response to Gerald Skoog."
Educational Leadership 38(2):157, November, 1980.
EJ 236 667 CIJE, 1981

Broad, William J.
"Creationists Limit Scope of Evolution Case."
Science 211(4488):1331-32, March, 1981.
EJ 242 996 CIJE, 1981

Callaghan, Catherine A.
"Evolution and Creationist Arguments."
American Biology Teacher 42(7):422-25, October, 1980.
EJ 232 976 CIJE, 1980

Chambers, Bette
"Why A Statement Affirming Evolution."
Humanist 37(1):23-4, January/February, 1977.
EJ 152 366 CIJE, 1977.

Cloud, Preston
" 'Scientific Creationism'—A New Inquisition Brewing."
Humanist 37(1):6-15. January/February, 1977.
EJ 152 364 CIJE, 1977

"Creation vs. Evolution: The Debate Goes On."
American School Board Journal 167(5):33-34, 38, May, 1980.
EJ 223 593 CIJE, 1980

Dawes, John A.
"A Simulation Model Approach to the Study of Evolution,"
Journal of College Science Teaching 7(2):102-04, November, 1977.
EJ 196 766 CIJE, 1977

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Desieno, Robert P.; Frederick D., Horn
"Literature and Science for a January Term: Darwin and Evolution."
Journal of College Science Teaching 3(1):61-63, Octover, 1973.
EJ 085 174 CIJE, 1973.

Gerlovich, Jack
"Creation, Evolution and Public Education." The Position of the Iowa Department of Public Instruction.
ED 199 074 RIE, July, 1981

Henig, Robin Marantz.
"The Battle Continues: Evolution Called A 'Religion,' Creationism Defended as a 'Science'."
Bioscience 29(9):513-16, September, 1979.
EJ 210 125 CIJE, 1979

Kyle, William C., Jr.
"Should 'Scientific' Creation and the Science of Evolution Be Taught With Equal Emphasis."
Journal of Research in Science Teaching 17(6):519-27, November, 1980.
EJ 235 104 CIJE, 1980

Le Clerco, Frederic S.
"The Consitution and Creationism."
American Biology Teacher (36(3):139-145, March, 1974.
EJ 098 416 CIJE, 1974

Levin, Florence; Joy S. Lindbeck
"An Analysis of Selected Biology Textbooks for the Treatment of Controversial Issues."
ED 128 184 RIE, January, 1977

Levin, Florence S.; Joy S., Lindbeck
"An Analysis of Selected Biology Textbooks for the Treatment of Controversial Issues and Biosocial Problems."
Journal of Research in Science Teaching 16(3):199-203, May, 1979.
EJ 224 291 CIJE, 1979

Lightner, Jerry P.
"A Compendium of Information on the Theory of Evolution and the Evolution-Creationism Controversy."
ED 164 309 RIE, May, 1979

Mariner, James L.
"The Evolution-Creation Controversy in the United States."
Journal of Biological Education 11(1):6-11, March, 1977.
EJ 162 979 CIJE, 1977

Mayer, William V.
"Evolution: Theory or Dogma."
ED 093 572 RIE, November, 1975

Mayer, William V.
"The Incompatibility of Science and the Supernatural: A Response to Gerald Skoog."
Educational Leadership 38(2):158-59, November, 1980
EJ 236 668 CIJE, 1980

Moore, John A.
"Creationism in California."
Daedalus 103(3):173-190, Summer, 1974.
EJ 101 686 CIJE, 1974

Moore, John N.
"Evolution, Creation, and The Scientific Method."
American Biology Teacher 35(1):23-26, 34, January, 1973.
EJ 069 311 CIJE, 1973

Nelkin, Dorothy
"The Science-Textbook Controversies."
Scientific American 234(4):33-39, April, 1976
EJ 136 078 CIJE, 1976

Nelkin, Dorothy.
Science Textbook Controversies and the Politics of Equal Time.
ED 147 967 RIE, May, 1978

Orlich, Donald C.; And Others.
"Creationism in the Science Classroom."
Science Teacher 42(5):43-45, May, 1975.
EJ 119 935 CIJE, 1975.

Parker, Barbara.
"Creation vs. Evoluion: Teaching the Origin of Man."
American School Board Journal 167(3):25-26,31-34, March, 1980.
EJ 217714 CIJE, 1980

Pearson, Craig.
"Can Teachers Cope with Creationism."
Learning 9(7):31-33, February, 1981.
EJ 243 124 CIJE, 1981

Peterson, Glen E.
"They Should Stop Shooting Shoemakers Too, Shouldn't They."
American Biology Teacher 40(1):10-2, 42, January, 1978.
EJ 187 245 CIJE, 1979

Pipho, Chris.
"Scientific Creationism."
Compact 14(4):32,21, Winter, 1981.
EJ 242 302 CIJE, 1981.

Pipho, Chris.
"Scientific Creationism: A Case Study."
Education and Urban Society 13(2):219-33, February, 1981.
EJ 241 667 CIJE, 1981

Schodde, Peter.
"Contentious Issues in Science Teaching."
SASTA Journal 801:5-8, April, 1980.
EJ 228 859 CIJE, 1980

Skoog, Gerald.
"Does Creationism Belong in the Biology Curriculum."
American Biology Teacher 40(1):23-6,29, January, 1978.
EJ 187 248 CIJE, 1978

Skoog, Gerald.
"Legal Issues Involved in Evolution Vs. Creationism."
Educational Leadership 38(2):154-56, November, 1980
EJ 236 666 CIJE, 1980

"A Statement Affirming Evolution as a Principle of Science."
Humanist 37(1):4-5, January/February, 1977.
EJ 152 363 CIJE, 1977

Weinberg, Stanley L.
"A Reply to Walker, Mertens, and Hendrix on the Creation-Evolution Issue."
American Biology Teacher 39(9):548-9, December, 1977.
EJ 182 070 CIJE, 1977

Welch, Claude A.
"Evolution Theory and the Nature of Science."
Science Teacher 39(1):26-28, January, 1972.
EJ 048 333 CIJE, 1972

Prepared by Patricia E. Blosser, Associate Director, User Services

This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or the Department of Education.

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ERIC/SMEAC Science Education Fact Sheet Number 2 1981

Sources of Information on Science Careers

Science teachers, and their students, frequently are in need of information on science careers or science-related careers. Some interactive computer searching was done in order to determine the kinds of materials on this topic that could be found in ERIC. This fact sheet is designed to provide ERIC users with some ideas about terms they might use in searching ERIC as well as to identify some of the materials retrieved by computer searching.

Appropriate ERIC Descriptors

All ERIC clearinghouses use the terms found in the controlled vocabulary of the ERIC thesaurus, published by Oryx Press. Thesaurus terms are known as descriptors. Some descriptors are single words, e.g. career. Others are multi-word terms, e.g. science careers, career exploration.

Relevant terms for individuals wishing information about science careers are:

- careers
- science careers
- career awareness
- career choice
- career exploration
- career guidance
- employment
- occupations
- career education
- science

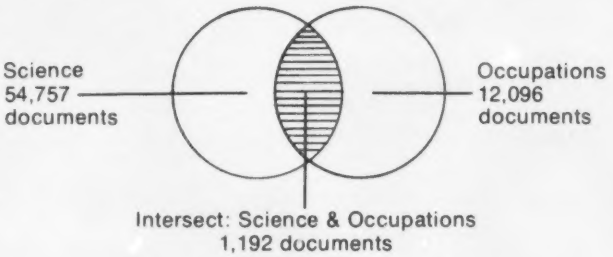
Results of Some Search Combinations

The Bibliographic Retrieval Services (BRS) system was used for the searches done for this fact sheet. The number of documents identified varied with the term, or combination of terms, used, as illustrated below:

Descriptor	Documents Identified
Science	54,757
Occupations	12,096
Employment	20,825
Career Exploration	1,400
Career Awareness	1,860
Career Guidance	2,997
Career Choice	3,723
Career Education	7,548
Science Careers	312

By scanning this list, the reader can see that even the apparently most restrictive descriptor: "science careers" still retrieves a large number of documents (312). It seemed a good idea to try some combinations of descriptors, to see how many documents would be identified when terms were combined.

Combining terms allows the searcher to retrieve documents in which several appropriate descriptors are used. For example, when the descriptor "science" was combined with "occupations," 1,192 documents containing both of these terms were identified. This situation might be thought of in terms of a Venn diagram:



The results of combined terms were as follows:

Combination of Descriptors	Documents Identified
Science & Occupations	1,192
Science & Employment	1,393
Science & Career Exploration	131
Science & Career Awareness	1,860
Science & Career Guidance	2,997
Science & Career Choice	307
Science & Career Education	632
Science Careers & Career Exploration	14
Science Careers & Career Awareness	33
Science Careers & Career Choice	51
Science Careers & Career Education	65
Science & Career Awareness or Career Educ	709
Science Careers & Career Awareness or Career Education	81

Advice to ERIC Users

Persons interested in finding information about science careers or science-related careers should be able to identify many documents in the ERIC data base. Those individuals interested in a comprehensive search should use some combination of single word terms with the descriptor "science." Those who want to scan fewer documents would be advised to use the descriptor "science careers" with some other term or terms in order to limit the amount of documents identified by the search process.

Some Representative Documents

The following list contains the ED or EJ number, author, document title, and source of ERIC abstract (RIE = *Resources in Education* or CIJE = *Current Index to Journals in Education*) of some representative materials identified by ERIC searches.

Using "science careers" combined with either "career awareness" or "career education," these were some of the materials identified:

ED 199 050
Hollin, DeWayne
Vocational-Technical Marine Career Opportunities in Texas.
RIE July 1981

ED 198 336
Exploring Careers. Scientific and Technical Occupations.
RIE July 1981

ED 196 700
Environmental Protection Careers Guidebook.
RIE May 1981

ED 187 997
Project Choice #113. A Career Unit for Grades 3 and 4. Scientists.
(Science and Engineering Occupations Career Cluster)
RIE Nov. 1980

ED 187 963
Project Choice #9. A Career Education Unit for Junior High School. Science and Careers. (Science and Engineering Occupations Career Cluster)
RIE Nov. 1980

EJ 223 336
Ciborowski, Paul J.
"A Career Education Seminar for High School Females."
CIJE Oct. 1980

EJ 220 053
Clapper, Thomas W.
"A School-Community Science Experience: Great Valley's Chemistry-Industry Awareness Program."
CIJE Aug. 1980

ED 166 056
Marine Related Occupations: A Primer for High School Students. Insight 7.
RIE June 1979

ED 161 764
Winter, Charles A.
Opportunities in Biological Science Careers.
RIE March 1979

ED 156 870
Ondrake, Greg.
Twenty Careers and Classroom Experiences for Teaching Science.
RIE Dec. 1978

ED 139 380
Edwards, Judith B. and Others
Elements of Computer Careers.
RIE Oct. 1977

ED 120 417
Thal-Larsen, Margaret and Gerald R. Parrish
Career Guidance for Science Students: Systems, Practices and Data Base.
RIE Aug. 1976

ED 106 546
Sleep, Gerald and Others
Career Activities in Science: Grades 7-12.
RIE Oct. 1975

Some of the documents retrieved by a search using the terms "science careers" and "career education" or "occupations" are:

ED 200 354
MacCorquodale, Patricia
Interest in Science Course and Careers: A Comparison of Mexican-American and Anglo Students.
RIE Aug. 1981

EJ 239 406
Cook, Don
"Training and Manpower in Environmental Quality."
CIJE May 1981

EJ 238 208
Smith, Elsie J.
"Career Development of Minorities in Nontraditional Fields."
CIJE May 1981

ED 155 017
Elardi, James
Ocean Careers: A Survey of Opportunities and Requirements
RIE Oct. 1978

ED 120 348
Zupfer, John and Others
Career Related Science Units, Teacher Edition
RIE Aug. 1976

ED 110 341
Keeves, John P. and Alison D. Read
Sex Differences in Preparing for Scientific Occupations.
RIE Dec. 1975

ED 107 783
Alexander, Elaine A.
Career Education in the Seventh Grade Science Class. Career Development Project.
RIE Nov. 1975

ED 106 573
Career Orientation: Grade 7 and 8: A Unified Approach: Science Careers. Activity Manual
RIE Oct. 1975

ED 094 208
Rever, Philip R.
Scientific and Technical Careers: Factors Influencing the Development During the Educational Years, Monograph 12. Final Report.
RIE Dec. 1974

EJ 216 626
Prien, John D. Jr.
"The National Executive Committee on Guidance: Helping Young People Make Informed Decisions,"
CIJE June 1980

EJ 194 857
Simmons, Barbara and Eddie Whitfield
"Opening Doors to Science Careers."
CIJE May 1979

EJ 187 284
Kastrinos, William
"Factors to Consider in Choosing a Health Profession."
CIJE June 1979

EJ 174 442
Davis, Lou
"Where Will I Work in 1992?"
CIJE June 1978

For more complete listings of relevant documents, the readers of this fact sheet are advised to have a computer search run using the most appropriate combination of descriptors for their interests. Readers who are uncertain of the search services available in their state should write to the SMEAC Information Reference Center and request a listing of search services. (There is no charge for this listing).

Persons who want to maintain current awareness of the materials being placed in the ERIC system each month that deal with science career information should scan the subject index of the monthly issues of *Resources in Education* and *Current Index to Journals in Education* to determine what the various clearinghouses have placed in the ERIC system.

Prepared by Patricia E. Blosser, Associate Director, User Services

This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or the Department of Education.

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ERIC/SMEAC Science Education Fact Sheet Number 3 **1981**

Sources of Information About Science Activities for Special Students

This science education fact sheet has been designed to provide teachers with some sources of information related to science activities that might be used with special students. For the purpose of this fact sheet "special students" includes not only those students with learning disabilities or physical disabilities but also those students considered to be gifted. References have been categorized on the basis of the disability or condition involved.

A computer search of the ERIC data base was run, using the descriptor "science activities" in combination with the following other descriptors:

handicapped students
handicapped children
visually handicapped
visual impairments
learning disabilities
perceptual handicaps
physical disabilities
physically handicapped
special health problems
speech handicaps
mainstreaming
special education
mild disabilities
gifted.

Some combinations of descriptors did not retrieve any documents. For example, science activities combined with special health problems resulted in 0 hits (no documents) as did science activities combined with speech handicaps.

Persons searching the ERIC data base need to be aware of the fact that some changes in descriptors relevant to special students have occurred. From 1966-1980 the terms handicapped, handicapped children, handicapped students were acceptable descriptors to use in searching the ERIC data base. Beginning in March, 1980, the term disabilities replaced the handicapped terms. As of March, 1980, handicapped, handicapped children, and handicapped students became invalid descriptors. ERIC searchers now need to search by coordinating (combining) specific descriptors with the disabilities term, or use disabilities with the appropriate student or mandatory age or educational level descriptors if their search is a broad one.

Some documents or journal articles were retrieved by more than one combination of descriptors, apparently because more than one disability was used to characterize the contents of the publication. Because fact sheets are brief, a document will be cited only the first time it was retrieved by the computer search.

Science Activities + Handicapped Students/Children

Spann, Margaret and Connie Cowan
Life Science. A Curriculum Guide
ED 113 565

Presents life science curriculum designed for students enrolled in the coordinated vocational education and training for disadvantaged and handicapped youth program to enable them to fulfill the laboratory science course requirement for graduation from Oklahoma high schools.

Francoeur, Pearl and Bihah Eilam
"Teaching the Mammalian Heart to the Visually Handicapped — A Lesson in Concrete Experience"
The Science Teacher 42(10):8-11, Dec., 1975
EJ 130 198

Programed instruction is used with concrete experiences and raised diagrams to teach the mammalian heart to both sighted and visually handicapped students.

Billings, Gilbert and others
"Lighting Up Science for the Visually Impaired"
The Science Teacher 47(3):28-29, Mar., 1980
EJ 220 067

Science activities using tactile and auditory aids to help visually impaired students learn biology are described.

Karnes, Merle B. and Paula S. Strong
Nurturing Academic Talent in Early Childhood: Science
ED 161 530

Guide for educating young gifted/talented handicapped children and gifted children with no handicaps is presented.

Yonkers City School District, N.Y.
Classroom Management Systems for Implementation of Individualized Instruction: Utilizing Science in Programs for the Handicapped.
ED 115 032

Contains 80 science activity cards designed to teach various science topics. Each activity card contains information about objectives, materials and procedures.

Post, Thomas R. and others
"Laboratory-Based Mathematics and Science for the Handicapped Child."
Science and Children 13(6):41-43, Mar., 1976
EJ 138 574

Suggestions are given for planning a laboratory-based program, and guidelines for teachers of both handicapped and non-handicapped students are included.

Watling, Carol and Raymond E. Hallard
"The Sea Beside Us"
Teaching Exceptional Children 7(1):26-28, Feb., 1974
EJ 109 312

Outdoor and overnight experiences for handicapped children are described.

Vannan, Donald A.
"Science Activities and the Retarded Child"
Science Activities Dec/Jan., 1974, pp. 37-38
EJ 091 787

Ten resource articles and books useful to special education and elementary teachers who wish to provide science activities for slow learners and retarded students are briefly discussed.

Thier, Herbert D. and Doris E. Hadary
"We Can Do It, Too"
Science and Children 11(4):7-9, Dec., 1973
EJ 091 642

Describes some adaptations of science exercises found in the program, "Adapting Science Materials for the Blind."

Science Activities + Visually Handicapped/Visually Impaired

Ricker, Kenneth S.
Teaching Biology to Visually Handicapped Students. Resource Manual
ED 191 660

Numerous techniques for adapting science activities in introductory courses in biology in which microscopes are used extensively are presented.

Thier, Marlene
"Utilizing Science Experiences for Developing Visual Perception Skills"
Science and Children 13(6):39-40, Mar., 1976
EJ 138 573

Alternative approaches for developing visual perception skills found in using selected science experiences are described.

Kaufman, Abraham S.
"Tutoring a Visually Handicapped Student in High School Chemistry"
New Outlook for the Blind 65(10):313-317, Dec., 1971
EJ 048 860

Teacher-developed materials and techniques are described.

DeLucchi, Linda and others
"Science Activities for the Visually Impaired: Developing a Model"
Exceptional Children 46(4):287-288, Jan., 1980
EJ 223 680

Describes the Science Activities for the Visually Impaired (SAVI) program developed for use with blind and visually impaired children aged 9-12.

Kaschner, Susan K.
"Viewing the Earth with Closed Eyes"
Science Activities 15(3):12-13, 1978.
EJ 194 937

Describes earth science activities for the visually impaired student.

Tallman, Dennis E.
"A pH Titration Apparatus for the Blind Student"
Journal of Chemical Education 55(9):605-606, Sept., 1978
EJ 191 327

Describes the apparatus used and experiments performed in a freshman analytical chemistry course by a blind student.

Science Activities + Learning Disabilities

Ball, Daniel W.
ESS/Special Education Teacher's Guide
ED 173 071

Describes ESS units that can be used with students in grades 1-12 in special education programs.

Owens, Jean
Project Success for the SLD Child, Curriculum Modification
ED 089 483

Some science activities on plant growth are included in this guide for teaching language disabled elementary students.

Science Activities + Physical Disabilities/Physically Handicapped

Jones, Alan and Anthony Barnett
"Science for the Physically Handicapped"
Special Education: Forward Trends 7(3):25-28, Sept., 1980
EJ 238 815

Several experiments designed to provide "safe" science activities for junior high school physically handicapped students are described.

Science Activities + Special Education

Jennings, Frederick and Peter M. Metro
Ecology for the Exceptional Child
ED 180 814

This guide presents a student-centered program of outdoor education for students of differing exceptionalities.

Schery, Stephen D.
"Science Classes for Mentally Retarded Adults"
The Science Teacher 42(1):44-46, Jan., 1975
EJ 109 971

A science program for the mentally retarded institutionalized adult is discussed.

Science Activities + Gifted

Romey, William D.
Teaching the Gifted and Talented in the Science Classroom
ED 197 522

Guidelines for presenting science to the gifted and talented are presented. Science activities are provided. Basic skills as they related to the gifted are discussed.

Doyle, Charles
"An Energy Education Unit for Upper Elementary Grades"
NJEA Review 54(3):26-27, Nov., 1980
EJ 233 475

A two-part unit on energy designed for gifted fifth and sixth grade students is described.

Landis, Melodee
The Class Menagerie. A Compilation of Exciting Activities for Secondary School Students
ED 162 471

Science activities are included in the information presented about activities designed to foster growth in creativity and upper level thinking of secondary school students who are classified as gifted.

James, Sally
Project Success: Electricity
ED 150 784
DeMaray, Bryan
Project Success: Marine Science
ED 150 783

Packets of materials designed to teach these topics to gifted elementary students include pre-post tests, vocabulary lists, techniques and projects.

Science: Curriculum Guide for Teaching Gifted Children Science in Grades One Through Three: A Sample Ecology Unit
ED 146 772

Included is a sample teaching-learning plan for an ecology unit as well as eight sample lesson plans.

Prepared by Patricia E. Blosser, Associate Director, User Services

This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or the Department of Education.

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ERIC/SMEAC Science Education Fact Sheet Number 4 1981

The Role of the Laboratory in Science Teaching

In these days of increased costs and decreased funding for education, science teachers are concerned that budget cuts will result in less funds for supplies and equipment for laboratory activities. The demand for educational accountability emphasizes, for many persons, student achievement which is determined in large part by paper and pencil tests. Teachers and administrators seeking support for the continuation of laboratory instruction in science can find information in the ERIC data base related to the role of the science laboratory.

What Literature is Available in ERIC?

A search of the ERIC data base using terms such as "science laboratories" and "science instruction" would result in the identification of a large number of documents. If the term "educational research" were added to the search, much material would still be retrieved. A large amount of the literature on the role of the laboratory is opinion-based rather than research-based. Related to these opinions are descriptions of goals and objectives science educators considered appropriate for science teaching and learning. Research-based literature contains information on how well (if at all) these goals are attained by students as a result of experiences in the science laboratory.

What Do People Believe About the Role of the Laboratory?

A long-held belief is that the laboratory is an important means of instruction in science. Laboratory activities were used in high school chemistry in the 1880's (Fay, 1931). The use of laboratory activities in high school physics classes was given support by the development, in 1886, of Harvard University's list of physics experiments to be included in high school physics classes for students wishing to enroll at Harvard (Moyer, 1976). Laboratory instruction was considered essential because it provided for training in observation, supplied detailed information, and aroused pupils' interest—reasons for using the laboratory that are still accepted almost 100 years later.

Contributors to the 59th yearbook of the National Society for the Study of Education, *Rethinking Science Education*, stipulated that every laboratory activity should have a clear-cut educational purpose and identified five purposes that laboratory activities might serve: (1) to add reality to textbook material; (2) to develop first-hand familiarity with tools, materials, and techniques of science; (3) to allow students to demonstrate to themselves something they already know to be true; (4) to give students opportunities to pit their laboratory skills against par in seeking experimental answers; and (5) to create opportunities wherein students predict events or circumstances and then design experiments to test the accuracy of their predictions (Henry, 1960, pp. 245-247).

The use of the laboratory as an instructional technique was given support by the science course improvement projects funded by the National Science Foundation in the 1960's. "Science as inquiry" was the slogan. Teachers were encouraged to restructure their teaching methods so that students were required to take an active role in learning and to gain skill in knowing what questions to ask of a report of inquiry, when to ask these questions, and where to find the answers. Teaching science as dogma was to be avoided.

More recently Shulman and Tamir identified five groups of objectives that may be achieved through the use of the laboratory in science classes: (1) skills—manipulative, inquiry, investigative, organizational, communicative; (2) concepts—for example, hypothesis, theoretical model, taxonomic category; (3) cognitive abilities—critical thinking, problem solving, application, analysis, synthesis, evaluation, decision making, creativity; (4) understanding the nature of science—scientific enterprise, scientists and how they work, existence of multiplicity of scientific methods, interrelationships between science and technology and among the various disciplines of science; and (5) attitudes—for example, curiosity, interest, risk taking, objectivity, precision, confidence, perseverence, satisfaction, responsibility, consensus, collaboration, and liking science (Travers, 1973, p. 1119).

What Do Critics of the Laboratory Say?

Just as the laboratory has long had its advocates, it has also had its critics. Establishing science laboratories involves more expense than purchasing textbooks does, not to mention the continued need to replenish consumable supplies and repair or replace equipment. Scheduling double periods for laboratory instruction may be a time-consuming administrative process. Teachers of other content areas may not recognize the demands involved in conducting laboratory activities and may consider that their science colleagues have lighter teaching schedules.

Even within the science education community laboratories were subject to criticism. The demonstrative or verification function of the laboratory was considered to be overemphasized, with little emphasis placed on the functions of providing students tangible experience of some of the problems dealt with by scientists or of the difficulty of acquiring data. Laboratory activities were not experimental and quantitative but were illustrative. They did not convey to students an accurate picture of the nature, method and spirit of science.

What Help Does Educational Research Provide?

When supporters of science laboratory activities turn to educational research, they find mixed results. Much of the educational research literature is produced from doctoral studies. Such studies are usually an individual's first attempt at research. Most are single studies, with no further follow-up of the subjects who were involved. When educational re-

search focused on instruction is analyzed, much of it is found to be of the comparative variety. Students receiving method A are compared with similar students receiving method B. Frequently one of these methods is referred to as the "traditional" approach to instruction in science. The reader is often left to his/her own devices to determine what took place in the traditional approach even if the experimental treatment is described in detail (and this does not always occur).

Science education researchers have looked at the influence of the laboratory on achievement; attitudes; reasoning, critical thinking, scientific thinking, cognitive style; understanding science; science process skills; laboratory skills or manipulative skills; interests; dogmatism; retention in a science course; and the ability to do independent work—among other variables (Blosser, 1980). Many of these studies resulted in the finding of no significant differences between groups.

Does this mean there is no support to be found in educational research for the continuation of laboratory activities in science classes? Certainly not.

What are Some Positive Findings?

Results from at least two studies were that laboratory activities appear to be helpful to students rated as medium to low in achievement on pretest measures (Boghai, 1979; Grozier, 1969). Godomsky (1971) found that laboratory instruction did increase students' problem-solving ability in physical chemistry and that the laboratory could be a valuable instructional technique in chemistry if experiments were genuine problems without explicit directions. Comber and Keeves (1973), in their study of science education in 19 countries, reported that in six countries where 10-year-old students made observations and did experiments in their schools, the level of achievement in science was higher than in schools where students did not perform these activities. Researchers (McKinnon, 1976; McDermott et al., 1980) working with older, disadvantaged students report the importance of laboratory activities. In the laboratory setting, activities can be designed to create disequilibration to encourage cognitive development, scientific ideas can be introduced, concrete examples and the opportunity to manipulate materials can be provided. Students using graphs, diagrams, and verbal statements can relate these representations to the real world.

What's the Problem?

If research data exist that support the role of the laboratory in science teaching, why are educators still faced with the problem of defending laboratory activities as an essential component of the science curriculum? Often the need to be educationally accountable has been translated as the need to increase test scores. Complex ideas and relationships are difficult to test in a multiple-choice format and areas emphasized are those which can be measured by such tests. Such a practice limits what is taught. Objectives for teaching science are broader than just the accumulation of a store of factual information.

Data from the national survey by Weiss (1978) and the case studies (Stake, 1978) show that laboratory work and/or hands-on science activities are used less frequently than science educators would desire. Teachers defend this lack by talk of student apathy and of problems involved in managing laboratory activities, as well as in maintaining science facilities and replacing equipment and supplies.

However, if we believe that knowledge begins with the assimilation of data from the environment and that individuals learn by having the opportunity to explore and interact with materials, we have an obligation to provide laboratory activities that allow our students to have such opportunities and to experience something of the nature, method and spirit of science.

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This publication was prepared with funding from the National Institute of Education, U.S. Department of Education under contract no. 400-78-0004. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or the Department of Education.